ORIGINAL ARTICLE

Night-shift work and cardiovascular risk among employees of a public university

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Summary

Objective: To estimate the association between night-shift work and high cardiovascular risk. **Methods:** Cross-sectional study carried out with 211 workers of both genders, aged between 30 and 64 years, working on the health campus of a public university in the state of Minas Gerais, Brazil. Night-shift work was defined as a work shift between 7 pm and 7 am, and high cardiovascular risk was calculated based on the Framingham score. The association between night-shift work and high cardiovascular risk was estimated by the prevalence ratio (PR) and its 95% confidence interval (95% CI) after adjusting for potential confounding factors, calculated by Poisson regression. **Results:** Night-shift work was performed by 38.4% of the individuals, and high cardiovascular risk was diagnosed in 28% of the sample. Hypertension was more prevalent among night-shift compared with day-shift workers ($p < 0.05$). In the bivariate analysis, night-shift work, passive and high job strain categories at the demand-control scale, work time > 120 months, schooling ≥ 9 years, family income ≥ 6 minimum wages, level 2 abdominal obesity, and triglyceride levels ≥ 150 mg/dL were associated with high cardiovascular risk ($p < 0.05$). After multivariate analysis, night-shift work remained independently associated with high cardiovascular risk (PR = 1.67; 95% CI = 1.10-2.54). **Conclusion:** The prevalence of high cardiovascular risk was 67% higher among night-shift workers. This association should be considered when discussing the promotion of workers' health regarding changes in the work process.

Keywords: Night work; risk factors; cardiovascular diseases; public health; nursing.

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Introduction

Cardiovascular diseases (CVDs) represent a significant worldwide public health problem and are responsible for one-third of all deaths in the world's population[1].

In Brazil, this group of diseases accounted for 29.4% of all deaths in 2007, becoming the main leading cause of death[2]. Moreover, CVDs result in a high number of hospitalizations, generating great social and economic costs. According to the Ministry of Health, almost 20% of the total amount spent to cover admissions carried out through the Brazilian Unified Health System (Sistema Único de Saúde – SUS) in 2006 was used to pay for hospitalizations due to CVDs[3]. This group of diseases is also responsible for the high number of requests for early retirement due to disability, and the granting of medical leaves[4].

Due to this epidemiological profile, the scientific community has sought to identify the risk factors of CVDs in order to establish prevention, control, and treatment measures. Thus, male gender[5], age[5], hypertension[5], smoking[5], hypercholesterolemia[5], low levels of high-density cholesterol (HDL-c)[5], diabetes *mellitus*[5], low level of schooling[6], low income[6], sedentary lifestyle[7], obesity[7], hypertriglyceridemia[7], and psycho-emotional stress[8] stand out as determinants of CVDs. Regarding this last risk factor, it seems to be related to greater reactivity of the cardiovascular system, contributing to the development of CVDs[8].

In this context, many authors agree that the workplace is an important source of psycho-emotional stress, increasing the number of employees affected by CVDs[8]; one of the proposed models most commonly used worldwide to assess this exposure is Karasek's[9] demand-control and social support.

Moreover, another important question on this subject is the time of exposure to a high job strain. In this sense, among the Japanese population there is a phenomenon known as "karoshi", sudden death caused by overwork, which is becoming common, although the epidemiological evidence is limited[10].

Another hypothesis, currently under investigation, concerns the relationship between night-shift work and CVDs. An extensive review of scientific literature showed that night-shift workers are 40% more likely to be affected by CVDs when compared with those who work during the day[11]. Thus, this is a topic of great relevance, as night-shift work has become common worldwide, with approximately 22% of the population of industrialized countries performing their work activities during this period[12].

In Brazil, the effect of night-shift work on workers' health has been investigated in outcomes such as quality of sleep, fatigue, and psycho-emotional stress[13-15]. Only one study that has addressed the relationship of night-shift work with hypertension[16] was found, and high blood pressure levels are only one component of the overall assessment of cardiovascular risk. The exact physiopathological mechanism linking night-shift work and CVD is not yet completely understood; however, it is suspected that the main factor involved is the disturbance in the circadian rhythm[17,18].

Considering that this subject has been little explored in the Brazilian population, this study aimed to examine the independent association between night-shift work and high cardiovascular risk.

Methods

This is a cross-sectional epidemiological study carried out with employees of the health sciences campus of a public university in the State of Minas Gerais, which includes academic units, the School of Nursing, the School of Medicine, and the Clinical Hospital.

In the academic units, employees are classified as administrative staff (secretaries, drivers, cleaning staff, security guards, etc.) and faculty. At the hospital there are college level professionals (doctors, nurses, psychologists, nutritionists, physical therapists, occupational therapists, pharmacists, dentists, social workers, biologists, etc.), technical level professionals (nurse technicians, laboratory technicians), and the administrative technicians.

To meet the inclusion criterion, employees had to be between 30 and 65 years of age, as the Framingham score, the outcome variable of the present study can only be applied to this age range[5]. All employees who met this criterion were invited to participate in the study, totaling approximately 2,172 individuals, according to information from the human resources departments of the institutions. This invitation was made through disclosure on the websites, information boards of academic units and of the Clinical Hospital, and by handing printed invitations to the heads of all the departments of the institutions.

During the period of data collection, which occurred between April and November 2010, 218 employees voluntarily sought the research team. Participants who had any physical disability that precluded the measurement of anthropometric and clinical variables (n = 2), and pregnant women or those within one year of the postpartum period, as this condition could influence the results of anthropometric measurements, especially body weight and waist circumference (n = 5), were excluded. Thus, the final sample consisted of 211 participants of both genders.

Data collection was performed with the assistance of trained interviewers, who applied a questionnaire regarding demographic, socioeconomic, lifestyle aspects, and work activities. At the end of the interview a physical examination was performed to obtain anthropometric data and blood pressure levels. These procedures were performed in a room at the School of Nursing, equipped with the necessary materials for data collection. For the measurement of plasma lipids [total cholesterol, high-density cholesterol level (HDL-c), low-density level cholesterol (LDL-c), very low-density level cholesterol (VLDL-c), and triglycerides] and glucose, participants were referred to a hired clinical laboratory and instructed to fast for 12 to 14 hours, to abstain from alcohol for 48 hours, and to restrict physical activity prior to blood collection.

The exposure variable was the work shift, i.e., the period of day when the participants performed their work activities, which was categorized as day-shift (between 7 am and 7 pm) and night-shift (between 7 pm and 7 am). In the case of individuals whose work shift included the two periods, the one in which the participants spent most of the time performing their work activities was considered. This situation was observed in only four participants.

The outcome variable was the cardiovascular risk calculated by the Framingham score, which features the following components: (a) age, (b) total cholesterol, (c) HDL-c, (d) systolic and diastolic blood pressure, (e) smoking, (f) diagnosis of diabetes. Each of these elements was scored according to their specific values and the individual's gender[5]. In this study, participants were classified according to their cardiovascular risk as low/medium (< 20%) and high (≥ 20%).

Age was self-reported by the participant, while gender was evaluated by the interviewer.

The collected blood samples were centrifuged at the laboratory, and serum and plasma samples were stored in a refrigerator at 4°C and analyzed by regularly calibrated automated equipment (COBAS MIRA Plus, Roche). The concentrations of total cholesterol, triglycerides, and glucose were determined by enzymatic colorimetric method. The concentration of HDL-c was measured by enzymatic colorimetric method after precipitation of LDL-c and VLDL-c by phosphotungstic acid and magnesium chloride[19].

Blood pressure was measured after explaining the procedure to the patient, who had rested for at least 5 minutes prior to measurement in a quiet environment; did not have a full bladder; had not practiced physical exercises 60 to 90 minutes before measurement; had not consumed alcohol, coffee or food or smoked for 30 minutes before measurement; kept legs uncrossed, feet flat on the floor, leaned back on the chair, relaxed, and did not talk during the measurement[20]. In total, three measurements were made with two-minute intervals between them, using a calibrated mercury sphygmomanometer. At the end, the mean of three readings was recorded as a definitive value for the data analysis.

Smoking was assessed by the following questions: "Are you or have you ever been a smoker, i.e., have you smoked, throughout your life, at least 100 cigarettes?" and "How many cigarettes do you currently smoke per day?". In case of positive answer and the reporting of a number in the second, the participant was classified as a smoker. In case of positive initial response, but zero in the second, the participant was considered a former smoker. Finally, if the first answer was negative, the participant was classified as non-smoker. For the Framingham score calculation, nonsmokers and former smokers were grouped within the nonsmoker category.

Regarding the diagnosis of diabetes, hyperglycemia was chosen, using as reference value of fasting plasma glucose ≥ 100 mg/dL[21].

The covariates included in this study were job strain/demand-control, social support at work, number of working hours, time of work, years of schooling, monthly family income, physical activity during leisure time, waist circumference, and plasma triglyceride levels.

The information about demand-control and social support at work were obtained through the questionnaire proposed by Karasek[9], which has been widely used in healthcare to assess the association with CVDs[22], and has been validated in the Portuguese version for the Brazilian population[23].

To characterize the job demand, the questionnaire had five questions involving the following aspects: a) speed of work tasks performance; b) intense work; c) overwork; d) insufficient time to carry out work tasks; and e) conflicting demands. The questions had the following response options: "often," "sometimes," "rarely", and "never or almost never", and each one received a score of 1 to 4 (1 indicates low demand, and 4, high demand). The total score for work demand was obtained by adding the scores of each question, ranging from 5 to 20.

With respect to the control aspect of work, the questionnaire had six questions: a) opportunity to learn new things at work; b) specialized skills/knowledge required for the work; c) decision-making power in the work process; d) repetitive work; e) power to choose the activities to be performed; f) power to choose how to perform work activities. The response options and scores were the same provided for the demand alternatives at work (1 and 4 indicate low and high control, respectively). The total score for work control was obtained by adding up the scores for each question, ranging from 6 to 24.

The demand-control variable was constructed from the stratification of the scales of demand and control in two halves, based on the medians of total scores. Subsequently, these fractions were combined, generating four quadrants: a) low strain = low demand and high control; b) active = high demand and high control; c) passive = low demand and low control; d) high strain = high demand and low control.

The Karasek demand-control questionnaire also presents six questions about social support at work that involves the following aspects: a) working environment; b) relationship with other employees; c) support from co-workers; d) sympathy from co-workers when not having a good day; e) relationship with bosses; f) satisfaction when working with co-workers. The questions had the following response options: "strongly agree"; "agree more than disagree"; "disagree more than agree"; and "strongly disagree", and each one receives a score of 1 to 4 (1 indicates low support and 4 high support). The total score for social support at work was obtained by adding the scores for each question, ranging from 6 to 24.

To characterize the sample, this variable was dichotomized by dividing the scale into two halves, with the median as reference. The bottom of the scale indicated low support and the upper, high support.

The duration of working hours was calculated from the total hours of work performed by the participants. Subsequently, this variable was categorized as < 40 hours, 40 to 60 hours, and > 60 hours.

The time of work was evaluated from the total months during which the participant had performed work activities on the same work environment. This variable was categorized as < 60 months, 60 to 120 months, and > 120 months.

The years of schooling were self-reported by the participant. This variable was categorized as < 8 years, 9 to 11 years, and ≥ 12 years.

The participants' monthly family income was self-reported. They were asked to report the sum of the monthly earnings of each member of the family who had any type of work activity. This variable was divided into minimum wages (MWs) and the reference value in November 2010 was R$ 510.00. Subsequently, the family income was categorized as ≤ 2 MWs, 3 to 5 MWs, ≥ 6 MWs.

The estimation of physical activity measurement was performed using the long version of the International Physical Activity Questionnaire – IPAQ[24], widely used at national and international levels. The data analysis considered the "leisure physical activities" domain. The weekly frequency was multiplied by the time spent, in minutes, on each physical activity. Thus, the weekly load of physical activity during leisure time was obtained, which subsequently was categorized as sedentary (0 minutes), 1 to 149 minutes, and ≥ 150 minutes.

Waist circumference (WC) was measured according to standard recommendations[25]. In total, three WC measurements were performed and the mean value was considered for the final data analysis. An inelastic measuring tape was placed around the individual in the horizontal plane, positioning it at midpoint between the lower margin of the last rib and the upper part of the anterosuperior iliac crest. The measurement was obtained at the end of a normal exhalation to the nearest millimeter. Subsequently, the WC was categorized according to gender as normal [< 80 cm (female), < 94 cm (male)], risk level 1 [80 to 87.9 cm (female), 94 to 101.9 cm (male)], risk level 2 [≥ 88 cm (female), ≥ 102 cm (male)]. Triglyceride levels were categorized as < 150 mg/dL and ≥ 150 mg/dL[26].

Based on the information obtained in the interviews, a database was built using Epi Info release 3.3.2, and the analysis was developed using the Statistical Software for Professionals (STATA), release 10.0.

Sample characterization was performed by calculating the absolute and relative frequencies of work shift categories, according to demographic, socioeconomic, lifestyle, anthropometric, biochemical, and work environment variables, as well as the Framingham score and its components. Statistical differences were evaluated using Pearson's chi-square test.

The bivariate analysis was performed to assess the association between night-shift work and each covariate of interest (demand-control at work, social support at work, working hours, time at work, years of formal schooling, family income, physical activity at leisure time, WC, and plasma triglyceride levels) with high cardiovascular risk. The strength of associations was measured by prevalence ratios (PR) and their respective 95% confidence intervals (95% CI) using Poisson's regression with robust variance.

The independent association between night-shift work and high cardiovascular risk was assessed using Poisson's multiple regression model with robust variance, considering as variables of adjustment the demand-control at work, social support at work, number of working hours, time at work, years of formal schooling, monthly family income, physical activity during leisure time, WC, and plasma triglyceride levels. Except for the demand-control at work, all variables were used in the continuous format. Thus, the PR and respective 95% CI were calculated having as reference the category of day-shift work.

Moreover, the independent associations of the interactions between some covariables of interest (demand-control at work, social support at work, the time at work and working hours) and the night-shift work with high cardiovascular risk were tested. In all analyses, the level of statistical significance was set at 5% ($p < 0.05$).

The study was approved by the Committee of Ethics and Research in Humans of the Universidade Federal de Minas Gerais (Protocol No. 066/09). All participants signed the informed consent.

Results

The study sample consisted of 37.9% and 62.1% male and female participants, respectively. Of the total subjects, 61.6% performed their work activities during the day, while 38.4% worked at night (results not shown).

Most professionals were technicians or administrative staff, were classified in the active and high strain categories in the scale of demand-control at work, worked less than 40 hours a week, had worked less than 60 months in the current job, had 12 or more years of schooling, a family income of 3 to 6 minimum wages, and were sedentary. Level 2 abdominal obesity and hypertriglyceridemia were diagnosed in 34.1% and 23.7% of the total sample, respectively. There was a greater proportion of professional of technical level, high strain at work, working hours > 60 hours per week, time at work > 60 months, and 12 and more years of schooling among night-shift workers ($p < 0.05$) (Table 1).

Most participants were young (< 40 years old). The prevalence of hypercholesterolemia and low HDL-c were 55.4% and 45.9%, respectively. Hypertension was observed in 27.5%, while hyperglycemia was diagnosed in 16.1% of the participants. Smoking was a characteristic reported by

Table 1 – General characteristics of the studied sample according to work shift, Belo Horizonte, MG, 2010

Variables	Work shift			p-value*
	Day-shift	Night-shift	Total	
	n (%)	n (%)	n (%)	
Functional category				< 0.001
Administrative technicians	58 (44.6)	21 (26.6)	79 (37.4)	
Professors	12 (9.2)	0 (0.0)	12 (5.7)	
College-level professionals	21 (16.2)	17 (44.7)	38 (18.0)	
Technical-level professionals	39 (30.0)	43 (52.4)	82 (38.9)	
Demand-control of work				< 0.001
Low strain	30 (23.1)	12 (14.8)	42 (19.9)	
Active	50 (38.5)	13 (16.0)	63 (29.9)	
Passive	18 (13.8)	28 (34.6)	46 (21.8)	
High strain	32 (24.6)	28 (34.6)	60 (28.4)	
Social support at work				0.481
Low	68 (52.3)	38 (46.9)	106 (50.2)	
High	62 (47.7)	43 (53.1)	105 (49.8)	
Workload (hours/week)				0.023
< 40	75 (57.7)	33 (40.7)	108 (51.2)	
40-60	44 (33.8)	33 (40.7)	77 (36.5)	
> 60	11 (8.5)	15 (18.5)	26 (12.3)	
Time at work (months)				0.013
< 60	66 (50.8)	27 (33.3)	93 (44.1)	
60-120	24 (18.5)	28 (34.6)	52 (24.6)	
> 120	40 (30.8)	26 (32.1)	66 (31.3)	
Level of schooling (years)				0.008
1-8	17 (13.2)	12 (14.8)	29 (13.8)	
9-11	48 (37.2)	14 (17.3)	62 (29.5)	
≥ 12	64 (49.6)	55 (67.9)	119 (56.7)	
Family income (minimum wages)				0.816
≤ 2	31 (23.8)	18 (22.2)	49 (23.2)	
3–5	52 (40.0)	36 (44.4)	88 (41.7)	
≥ 6	47 (36.2)	27 (33.3)	74 (35.1)	
Physical activity (minutes/week)				0.717
Sedentary lifestyle	75 (57.7)	51 (63.0)	126 (59.7)	
1-149	22 (16.9)	11 (13.6)	33 (15.6)	
≥ 150	33 (25.4)	19 (23.5)	52 (24.6)	
Waist circumference (cm)				0.414
< 80 (F); < 94 (M)	56 (43.1)	31 (38.3)	87 (41.2)	
80 - 88 (F); 94-102 (M)	28 (21.5)	24 (29.6)	52 (24.6)	
≥ 88 (F); ≥ 102 (M)	46 (35.4)	26 (32.1)	72 (34.1)	
Triglycerides (mg/dL)				0.288
< 150	97 (74.6)	64 (79.0)	161 (76.3)	
≥ 150	33 (25.4)	17 (21.0)	50 (23.7)	

*Pearson's Chi-square; F, female sex; M, male sex.

12.3%, and high cardiovascular risk was present in 28% of the sample. The frequency of high cardiovascular risk was higher among night-shift workers, as well as the prevalence of hypertension ($p < 0.05$). The proportion of smokers was also higher among night-shift workers, although not statistically significant ($p = 0.066$) (Table 2).

In the bivariate analysis (Table 3), we observed that night-shift work (PR = 1.66, 95% CI = 1.08-2.55), the passive (PR = 3.20, 95% CI = 1.14- 8.97) and high strain categories (PR = 4.90, 95% CI = 1.85- 12.96) on the scale of demand-control, the time at work > 120 months (PR = 1.69, 95% CI = 1.02-2.80), level 2 abdominal obesity [(WC ≥ 88 cm - female, WC ≥ 102 cm - male), PR = 3.07, 95% CI = 1.75- 5.38], and triglyceride levels ≥ 150 mg/dL (PR = 3.11, 95% CI = 2.08-4.65) were positively associated with high cardiovascular risk. In contrast, schooling of

Table 2 – Characteristics of cardiovascular risk in the studied sample according to work shift, Belo Horizonte, MG, 2010

Variables	Work shift			p-value*
	Day-shift	Night-shift	Total	
	n (%)	n (%)	n (%)	
Age range (years)				0.171
30-34	41 (31.5)	30 (37.0)	71 (33.6)	
35-39	17 (13.1)	18 (22.2)	35 (16.6)	
40-44	15 (11.5)	11 (13.6)	26 (12.3)	
45-49	25 (19.2)	14 (17.3)	39 (18.5)	
50-54	22 (16.9)	5 (6.2)	27 (12.8)	
55-59	7 (5.4)	2 (2.5)	9 (4.3)	
60-64	3 (2.3)	1 (1.2)	4 (1.9)	
Total cholesterol (mg/dL)				0.219
< 160	16 (12.3)	15 (18.5)	31 (14.7)	
160-199	42 (32.2)	21 (25.9)	63 (29.9)	
200-239	32 (24.6)	28 (34.6)	60 (28.4)	
240-279	33 (25.4)	13 (16.0)	46 (21.8)	
≥ 280	7 (5.4)	4 (4.9)	11 (5.2)	
HDL-c (mg/dL)				0.885
< 35	24 (18.5)	17 (21.0)	41 (19.4)	
35-44	35 (26.9)	21 (25.9)	56 (26.5)	
45-49	20 (15.4)	13 (16.0)	33 (15.6)	
50-59	25 (19.2)	18 (22.2)	43 (20.4)	
≥ 60	26 (20.0)	12 (14.8)	38 (18.0)	
SBP/DBP (mmHg)+				0.005
< 120 / < 80	50 (38.5)	19 (23.5)	69 (32.7)	
120-129 / 80-84	18 (13.8)	24 (29.6)	42 (19.9)	
130-139 / 85-89	31 (23.8)	11 (13.6)	42 (19.9)	
140-159 / 90-99	22 (16.9)	16 (19.8)	38 (18.0)	
≥ 160 / ≥ 100	9 (6.9)	11 (13.6)	20 (9.5)	
Hyperglycemia				0.572
No	109 (83.8)	68 (84.0)	177 (83.9)	
Yes	21 (16.2)	13 (16.0)	34 (16.1)	
Smoker				0.066
No	118 (90.8)	67 (82.7)	185 (87.7)	
Yes	12 (9.2)	14 (17.3)	26 (12.3)	
Cardiovascular risk (%)				0.020
< 20	101 (77.7)	51 (63.0)	152 (72.0)	
≥ 20	29 (22.3)	30 (37.0)	59 (28.0)	

*Pearson's chi-square; SBP, systolic blood pressure; DBP, diastolic blood pressure; +when pressures were in different categories, we chose the highest value.

Table 3 – Associations between night-shift work and the covariables of interest with high cardiovascular risk, Belo Horizonte, MG, 2010

Variables	High cardiovascular risk			p-value*
	n	%	PR (95% CI)	
Work shift				
Day-shift	29	22.3	1.00	-
Night-shift	30	37.0	1.66 (1.08-2.55)	0.021
Demand-control of work				
Low strain	4	9.5	1.00	-
Active	13	20.6	2.17 (0.76-6.21)	0.150
Passive	14	30.4	3.20 (1.14-8.97)	0.027
High strain	28	46.7	4.90 (1.85-12.96)	0.001
Social support at work				
Low	24	22.6	1.00	-
High	35	33.3	1.47 (0.94-2.29)	0.088
Workload (hours/week)				
< 40	32	29.6	1.00	-
40-60	20	26.0	0.88 (0.54-1.41)	0.589
> 60	7	26.9	0.91 (0.45-1.83)	0.788
Time at work (months)				
< 60	20	21.5	1.00	-
60-120	15	28.8	1.34 (0.75-2.39)	0.320
> 120	24	36.4	1.69 (1.02-2.80)	0.041
Level of schooling (years)				
1-8	15	51.7	1.00	-
9-11	16	25.8	0.50 (0.29-0.87)	0.013
≥ 12	28	23.5	0.45 (0.28-0.73)	0.001
Family income (minimum wages)				
≤ 2	19	38.8	1.00	-
3-5	25	28.4	0.73 (0.45-1.19)	0.208
≥ 6	15	20.3	0.52 (0.29-0.93)	0.027
Physical activity (minutes/week)				
Sedentary lifestyle	38	30.2	1.00	-
1-149	9	27.3	0.90 (0.49-1.68)	0.750
≥ 150	12	23.1	0.77 (0.44-1.35)	0.353
Waist circumference (cm)				
< 80 (F); < 94 (M)	13	14.9	1.00	-
80 - 88 (F); 94-102 (M)	13	25.0	1.67 (0.84-3.33)	0.143
≥ 88 (F); ≥ 102 (M)	33	45.8	3.07 (1.75-5.38)	< 0.001
Triglycerides (mg/dL)				
< 150	30	18.6	1.00	-
≥ 150	29	58.0	3.11 (2.08-4.65)	< 0.001

*Poisson regression with robust variances; F, female sex; M, male sex.

9 to 11 years (PR = 0.50, 95% CI = 0.29-0.87) and ≥ 12 years (PR = 0.45, 95% CI = 0.28-0.73), family income ≥ 6 minimum wages (PR = 0.52, 95% CI = 0.29-0.93) were negatively associated with high cardiovascular risk.

Night-shift work remained independently associated with increased cardiovascular risk after multivariate adjustment of the data (p = 0.005). Thus, the prevalence of high cardiovascular risk among night-shift workers was 67% higher than that of day-shift workers (PR = 1.67, 95% CI = 1.10-2.54) (Figure 1).

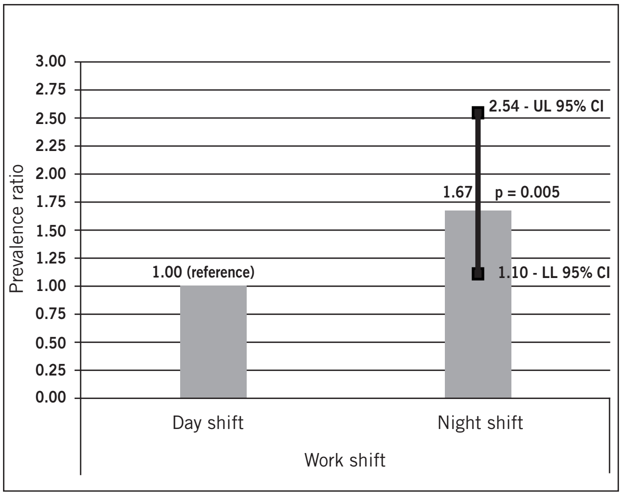

Figure 1 – Prevalence ratio and 95% confidence interval for the association between work shift and high cardiovascular risk, Belo Horizonte, MG, Brazil, 2010.
UL 95% CI, upper limit of the 95% confidence interval; LL 95% CI, lower limit of the 95% confidence interval. Prevalence ratio adjusted for demand-control of work, social support at work, workload, time at work, years of schooling, family income, total physical activity during leisure time, waist circumference, and triglycerides levels.

Discussion

In the present study, night-shift work was independently associated with high cardiovascular risk. The night-shift workers had a prevalence of cardiovascular risk that was 67% higher than in those who performed their work activities during the day, after multivariate adjustment of data. Therefore, night-shift work potentially increases the vulnerability to the occurrence of CVDs. Specifically in relation to the components of the Framingham risk score, hypertension and smoking were more prevalent among night-shift workers, although this association was slightly above the threshold for statistical significance of 5% (p = 0.066).

However, these results should be analyzed considering the following aspects: a) the possible influence of the "healthy worker bias", as, in general, night-shift work is performed by individuals with better health status[6]; b) as this is a cross-sectional study, the certainty is decreased in the temporality and causality of these associations; however, this is inherent to the study design.

In spite of these limitations, the present findings are consistent with those of other studies on the subject[27,28], although no investigations that used the Framingham score as a marker of cardiovascular risk were found, which was the outcome variable of this study. In a research carried out in Italy, night-shift work was associated with cardiovascular risk; however, the outcome marker used was metabolic syndrome, defined according to the International Diabetes Federation criteria[27]. A similar result was found in a cohort with 45 years of follow-up carried out in England, in which night-shift work remained independently associated with cardiovascular risk factors, such as global and abdominal obesities, in addition to high levels of C-reactive protein, after adjusting for socioeconomic variables and lifestyle habits, as well as occupational factors[28].

Several scientific studies published mainly from 1984 on, concluded that there is a strong association between night-shift work and CVD[29,30], including the estimate that this exposure factor increases the risk for CVD by 40%[11]. Some cohort studies have also shown the association between night-shift work and high risk for CVD[31,32]. In one, carried out with 5,517 Danish workers followed for 12 years, it was demonstrated that the professionals who performed their work activities during the night had a relative risk for CVD of 1.31 (95% CI = 1.06-1.63)[31]. In another study, which followed 6,711 Japanese workers for 14 years, there was a statistically significant increase in systolic and diastolic BP among night-shift workers. In some subjects, this increase was > 30%[32]. Results of a recently performed study with a longitudinal design showed, once again, that night-shift work increased the risk for CVD, further supporting this association[33].

The biological plausibility of the association between night-shift work and CVD may be due to disturbance in the circadian rhythm, changes in metabolic and hormonal functions, and a higher prevalence of smoking and inadequate diets[18,29,30]. The night-shift workers perform their work activities and rest at times that are opposite to the standard chronobiological pattern, i.e., sleeping during the period in which the body is prepared to engage in activities and working when physical and mental efficiency is generally low.

This change in the chronobiological pattern of the body generates chronobiological alterations in the normal circadian rhythm of blood pressure, which is characterized by a decrease in blood pressure at night, and an increase as soon as the day period starts[34]. Therefore, from the fluctuations that occur in blood pressure values, the circadian rhythm of night-shift workers undergoes changes in amplitude, i.e., the 24-hour standard curve changes. Instead of a decrease in the blood pressure value when evening period starts, the blood pressure remains at the same level expected for the day period[35]. Constant exposure to the variation in the amplitude of the circadian rhythm is responsible, in the long run, for the increase in mean blood pressure of night-shift workers, increasing the risk of CVD[34,35].

In the present study, the night-shift workers had a higher prevalence of arterial hypertension compared to day-shift workers (33.4% *versus* 23.8%, p = 0.005). Results of other studies, including some carried out in the Brazilian population[10], showed an association between night-shift work and arterial hypertension[36,37]. In a Brazilian study, 61 medical residents underwent ambulatory blood pressure monitoring (ABPM) during a 24-hour work shift in the emergency room, and during one day of normal work.

The mean 24-hour systolic and diastolic BP, and mean diastolic BP at rest were higher during night work in relation to day work (117 *versus* 113 mmHg, $p < 0.05$, 73 *versus* 69 mmHg, $p < 0.05$, 61 *versus* 58, $p < 0.05$, respectively). Furthermore, abnormally high BP mean values were more common in night-shift workers, in contrast with those working in daytime (19 *versus* 8, $p < 0.05$)[16]. In a survey of 1,838 female employees of a semiconductor manufacturing plant in northern Taiwan, it was observed that those who worked a fixed 12-hour night shift had significantly higher odds of developing arterial hypertension (OR = 2.30; 95% CI= 1.20–4.40) than the women who worked during the day, after multivariate adjustment for age, smoking, alcohol consumption, and working hours[36].

Regarding the habit of smoking, although the association was not significant in this study ($p = 0.066$), the number of smokers found among night-shift workers was almost twice of that found for day-shift workers. Other studies have also pointed out that smoking is more common among night-shift workers[32]. Moreover, the risk of starting to smoke, regardless of the educational level, has shown to be higher among professionals who perform their work activities at night[38].

The external validity of our findings should be interpreted with caution, as the sample is not probabilistic. However, this study provides the following characteristics: a) reliable measurements obtained through appropriate techniques, stringently performed by trained interviewers; b) adjustment of variables using multivariate analysis methods appropriate for the type of study design; c) high levels of strength of association.

Conclusion

In summary, we conclude that night shift work is associated with high cardiovascular risk. Therefore, this result should be incorporated in the discussions on the promotion of workers' health in relation to changes in the work process.

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